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O.C. Marsh

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OTHNIEL CHARLES MARSH.

AMONG the leading men of science in America, Professor Marsh was unquestionably one of the best known, and had one of the strongest personalities. The world-wide reputation he enjoyed, however, is not altogether attributable to the particular department of research in which he stood without a peer, for, added to his attainments in Vertebrate Paleontology, he possessed an unusual number of mental qualifications in other lines, as well as marked personal characteristics which made him known and felt where his science could never reach. His fame will undoubtedly rest on his work among the Fossil Vertebrates. Nevertheless, his energy and attainments in other directions were sufficient to have made for him a permanent record.

The nearness of the perspective at the present time renders it difficult properly to individualize and accord the true rank to the many important discoveries Marsh has made. He brought forth in such rapid succession so many astonishing things that the unexpected became the rule. The science of Vertebrate Paleontology could not assimilate new material so fast, and it will be years before the true significance and bearing of much that he has done will be understood. The constant stream of vertebrate riches which, from 1868 to 1899, flowed into the Yale University Museum from the Rocky Mountain region had a similar bewildering effect on Marsh, for

it was impossible for him to do more than seize on what appealed to him as the most salient. The work of the hour was to him of prime importance, whether it was for the determination of a new order of mammals or a new cusp on a tooth. Still, he seems to have had a just conception of relative values, for it will be found that he plucked the most luscious plums from the paleontological tree, and left chiefly the smaller or unripe and imperfect fruit untouched.

Another element in his success was seen in the improvement he made in the methods of collecting, preserving, and developing vertebrate fossils, so that even forms long known only from fragmentary remains were represented in his collections by almost complete specimens, presenting nearly the same degree of novelty shown in forms actually new.

In illustration of this, the Brontotheridæ, Ceratopsia, and the Mosasauria furnish excellent examples. Prout, in 1846, described, as *Palæotherium*, the fragment of a lower jaw from the Miocene of Nebraska, but Marsh first showed the affinities and range of forms in the group, through his splendid restoration of *Brontops* and the description of a number of allied types from nearly perfect material. Cope, in 1875, figured some pieces of bone of unknown relationships, which long remained in the paleontological scrap-basket.* Marsh, by his descriptions of the marvelous series of genera and species belonging to the Ceratopsia, demonstrated what these reptiles really were, and gave to science a nearly complete knowledge of one of the most bizarre monsters known. The first Mosasaur was obtained in Holland previous to 1785. It remained imperfectly known for nearly a century, when Marsh, by his contributions to its anatomy, made possible a clear understanding of its structure and affinities. In the same way it could be shown that to many old descriptions of genera and species based upon single teeth, he was enabled to add a knowledge of the remainder of the animal. Not only did he thus contribute the missing information in regard to many previously described forms, but he brought out a host of entirely new types, and made his science one of the most complete exponents of the doctrine of evolution.

* *Polygonax.*

As a collector, Marsh was seen at his best, and the collections he amassed during his forty-five years and more of activity in this direction form a lasting monument to his perseverance and foresight. A person with means and inclination may be supposed to have the necessary qualities for accomplishing his aims, whether they are first editions, autographs, or fossils, but had Marsh possessed no further qualifications than these, the results of his collecting would fall far short of what he really attained. He not only had the means and the inclination, but entered every field of acquisition with the dominating ambition to obtain everything there was in it, and leave not a single scrap behind. Every avenue of approach was made use of, and cost was often a secondary consideration. The nine-tenths, when attained, were only an additional stimulus for securing the remaining one-tenth. Of course, this ideal of completeness was often impossible of accomplishment, and yet it served to bring to the Yale University Museum collections which are unique from their richness and extent.

In making an estimate of his character, it must not be forgotten that he developed wholly without the influence of family and home ties, which in most men profoundly mark their mature life. Self-reliance is probably the strongest trait fostered by the absence of immediate family connections. This, Marsh possessed to an extraordinary degree, and it naturally led to a self-centering of his life and ambitions. Out of it came, also, an absence of the complete exchange of confidence which normally exists between intimate friends. Even where perfect confidence existed, he seldom revealed more about any particular matter than seemed to him necessary or than the circumstances really demanded. As a friend, he was kind, loyal, and generous. As a patron of science, he has seldom been equaled. Honest work in any department appealed to him strongly, and he was ever ready with aid and counsel, even at the expense of a personal sacrifice. His disposition was a most happy one, and he was always keenly appreciative of the humorous and ludicrous and fond of relating amusing experiences and anecdotes. The sunny side of his

character was nearly always uppermost, and the consideration of subjects of the greatest gravity was enlivened by constant sparkles of wit from his exhaustless store.

He was normally restive under restraint, and met all opposition with power and fearlessness. Having practically created the modern science of Vertebrate Paleontology in America, he resented any encroachment upon the particular fields of research in which he was engaged. This attitude frequently developed feelings of hostility in other investigators, and often alienated him from co-workers in his department of science. Nevertheless, he labored faithfully for the truth as revealed in his work, and was ready to change opinions and published statements whenever facts seemed to warrant it.

His esthetic sense was highly developed, and could be seen in the artistic care he bestowed upon his publications, but more especially on his home. His grounds are a model of landscape gardening. He delighted in his collections of modern paintings, the cultivation of orchids, and above all in the subtleties of Japanese art.

The world was not slow to recognize his contributions to knowledge, for during his lifetime he received a large number of tangible evidences of distinguished consideration in the way of academic and scientific honors, medals, and membership in learned societies.

In 1886, he received the degree of Doctor of Laws from Harvard University, and in the same year the honorary degree of Doctor of Philosophy from the University of Heidelberg. He occupied the chair of Paleontology in Yale University from 1866 to the time of his death. He was Vertebrate Paleontologist to the United States Geological Survey, and Honorary Curator of Vertebrate Paleontology in the United States National Museum.

He was President of the American Association for the Advancement of Science in 1878, and of the National Academy of Sciences from 1883 to 1895. As a presiding officer in the National Academy, he exercised the same amount of care that he bestowed upon his private affairs, and was an active and efficient leader.

In 1877, he was the recipient of the first Bigsby Medal awarded by the Geological Society of London, in recognition of his important labors on the Vertebrate Paleontology of the western territories of the United States. In 1898, the highly valued Cuvier Prize was given him by the French Academy, as one of the most able continuators of the science of which Cuvier had laid the foundations.

Prominent among the various societies of which he was a member may be mentioned :

The National Academy of Sciences; Institute of France; Royal Academy of Sciences, Brussels; Royal Bavarian Academy of Sciences, Munich; Royal Academy of Sciences, Bologna; Royal Danish Academy of Sciences, Copenhagen; Royal Irish Academy; Geological Society of London; Geological Society of Germany; American Philosophical Society; Academy of Natural Sciences, Philadelphia; Zoological Society of London; Société Impériale des Naturalistes, Moscow; Geological Society of America, etc., etc.

Few men have contributed more to THE AMERICAN JOURNAL OF SCIENCE than Professor Marsh. Nearly all his discoveries in science were first announced here, and it is the storehouse of most of his best work.

The subject of the present sketch was born near Lockport, New York, October 29, 1831. His parents were Caleb and Mary Peabody Marsh, formerly of Danvers (now Peabody), Massachusetts. His early education was obtained in the schools of Lockport and at the Wilson Collegiate Institute, Wilson, New York. A residence in a region rich in minerals and fossils is apt to attract the attention of a youth possessing healthy intelligence, and young Marsh soon shared his vacation time between the normal pursuits of shooting and fishing and the more unusual vocation of collecting minerals and fossils. By the time he was nineteen years old, he had thus acquired the taste for scientific subjects which was destined to grow and dominate the remainder of his life.

In 1851, he entered Phillips Academy at Andover, Massachusetts, and continued his studies there until graduation in

1856. He immediately entered the freshman class in Yale College, pursuing the regular classical course, and receiving the degree of B.A. in 1860. Graduate courses in the natural sciences were continued in the Sheffield Scientific School during the two years following (1861-62). The long summer vacations from 1851 to 1862 were occupied in collecting minerals and fossils from New York, New England, and Nova Scotia. To the latter region he made five trips during this interval, and obtained much valuable experience and scientific material. On his second visit (1855) he found some fossil vertebræ in the Coal Measures at South Joggins, representing a new and important vertebrate animal (*Eosaurus*). This discovery finally directed his studies into the channel which became his life-work. At this time, however, his interests were about equally divided between invertebrate paleontology and mineralogy, and it is worthy of note that his first scientific paper was published in THIS JOURNAL in 1861, under the title "The Gold of Nova Scotia."

The description of *Eosaurus* did not appear until 1862, seven years after its discovery. Even then it cannot be said that he had developed a strong liking for vertebrate paleontology. This closes the account of his student life in American schools.

The next three years were passed in study abroad, in the universities of Berlin, Heidelberg, and Breslau. He attended lectures and took special courses with H. Rose, G. Rose, Ehrenberg, Peters, Römer, Grube, and Goeppert. The vacations were occupied, as before, by geological excursions. He visited the most important localities in Europe, and obtained extensive collections. His official connection with Yale College began by his appointment, in 1866, to the chair of Professor of Paleontology. This title he held in high esteem, as it was the first established either in this country or elsewhere.

After attending the meeting of the American Association for the Advancement of Science at Chicago, in 1868, Marsh went as far west as Nebraska and Wyoming, along the route of the Union Pacific railroad, then just opened. This trip gave him a foretaste of the inexhaustible fossil riches of the

Rocky Mountain regions, and thenceforth his energies were mainly devoted to their exploration. Scientific expeditions to the western country were undertakings of considerable magnitude in those early days. There was but one railroad in the United States across a region measuring fifteen hundred miles square. White settlements were sparse and remote. Most of the country was unmapped, and with the exception of a few transcontinental trails, almost the whole western half of the continent, save the regions bordering the Pacific, was a boundless expanse of unknown arid plains, mountains, and valleys. Added to these conditions were the indigenous tribes of war-loving Indians, hostile to the whites. Under such circumstances, travel was slow, difficult, and dangerous. It was necessary to have an escort of soldiers and guides, experienced in western life and Indian warfare.

The first Yale Scientific Expedition was organized and engineered by Marsh in 1870. The party consisted of thirteen persons besides the officers and men of the military detachments who escorted them from various military posts along the route.* They explored the Pliocene deposits of Nebraska and the Miocene of northern Colorado, then crossing into Wyoming they made collections in the Eocene (Bridger Basin), and passing south discovered a new Eocene basin in Utah (Uinta Basin). At each of these places many important finds were made. The party next visited California, where minor collections were obtained from the Pliocene. Returning, they

* Members of the Yale party were O. C. Marsh, C. T. Ballard, C. W. Betts, A. H. Ewing, G. B. Grinnell, J. W. Griswold, J. R. Nicholson, C. McC. Reeve, J. M. Russell, H. B. Sargent, J. W. Wadsworth, E. Whitney, Jr., and H. D. Ziegler. The escorts consisted of:—

From Fort McPherson, Nebraska.—Commanding officer, Gen. Eugene A. Carr. Lieuts. Bernard Reilly, Jr., and Earl D. Thomas, in command of escort, 5th Cavalry; Buffalo Bill and Major Frank North, guides; and two Pawnee Indian scouts ("Lahurasoc" and "Tuckatelous").

From Fort D. A. Russell, Wyoming.—Commanding officer, Gen. John H. King. Capt. Robert H. Montgomery and Lieut. James McB. Stembel, in command of escort, 5th Cavalry.

From Fort Bridger, Wyoming.—Commanding officer, Major R. S. LaMotte. Lieut. W. N. Wann, in command of escort, 13th Infantry; Mexican guide ("Joe Talemans").

From Fort Wallace, Kansas.—Commanding officer, Gen. Henry C. Bankhead. Ed. Lane, guide; Lieut. Charles Braden, in command of rescue troop.

spent some time exploring the Cretaceous beds of western Kansas, so rich in the remains of aquatic reptiles, and now famous for having furnished the first toothed birds and American toothless flying reptiles.

The second, third, and fourth Yale Scientific Expeditions (1871, 1872, 1873) were modeled after the first. New regions in the West were visited, and extensive series of remains of extinct animals were obtained. Coincident with these discoveries, Marsh published frequent scientific papers describing and illustrating the more important forms, and paleontological literature was enriched by the addition of more startling and wonderful types of animal life than had been hitherto known from the rest of the world.

Owing to Indian outbreaks and a general uneasiness in the West, no regular expedition was organized in 1875. Late in the fall, however, Marsh went to the Bad Lands of Nebraska and Dakota accompanied by an escort from Fort Laramie to the Red Cloud Agency. The consent of the Indians was deemed necessary to search for fossil bones in their country. A treaty was obtained with difficulty and then assistance was withheld. Nevertheless, with great hardship owing to extreme cold, the party succeeded in reaching the desired region, and made important discoveries, among which numerous remains of the gigantic Brontotheridæ are the most noteworthy.

It was at this time that he became aware of the frauds practiced upon the Indians by the agents of the Government, and the way the Government was in turn defrauded through their misrepresentations. He promised Red Cloud to bring the matter before the President for redress. This was done with signal success, resulting in the complete routing of the Indian Ring, and the downfall of the Secretary of the Interior as well as in his political death.

The rapid settlement and development of the West rendered it no longer necessary to fit out expensive expeditions, especially as many of the localities were easily accessible by railroad. Therefore, after 1876, local collectors and small parties were employed in continuing the work of collecting fossils so successfully begun by the Yale Scientific Expeditions. Nearly every season, however, Marsh visited the localities where work

was being carried on, and some time each year was spent in reconnaissance for new fields of labor.

The right wing of the Peabody Museum was completed in 1875, the means having been furnished by Mr. George Peabody largely through the influence of his nephew, Professor Marsh. It was to his uncle, also, that Marsh was indebted for his educational advantages and for his private fortune. The old Yale Cabinet had long been outgrown. The rooms became so crowded that for years there was only space for a chalk line dividing the different departments. The collections which had been accumulating during so many previous years found a commodious home in the new museum, and work was resumed with great activity under more favorable conditions than heretofore. Huxley's visit in the following year was a further stimulus to higher work, as is clearly evinced in the celebrated Nashville address mentioned elsewhere.

The National Government had not altogether neglected its opportunities for scientific research in the West during this period, though the results in the way of substantial collections were far inferior to those Marsh had obtained. For some time previous to 1878, there were four separate surveys, two under the Engineer Department of the Army and two others, extensions of private expeditions, under the Department of the Interior. In the reorganization ordered by Congress in 1878, Marsh, as acting President of the National Academy of Sciences, was the chief instrument in effecting a consolidation and in defining the relations of the present United States Geological Survey with the general Government and with the United States National Museum. The wisdom of this change was at once apparent, and the Survey is now often considered one of the most economical, best managed, and productive departments of the Government.

After repeated solicitation and with promises of material aid in the way of publication and collections, Marsh, in 1882, accepted the appointment of Vertebrate Paleontologist to the United States Geological Survey. This position he held to the time of his death, although the field work for the survey was terminated in 1892. His connection with the Survey gave him increased facilities for publication and for prosecuting explora-

tions in the West. He successively projected the publication of a number of large monographs on various groups of vertebrate fossils. It is a great misfortune that but two of these were ever finished by the author. The monograph of the Odontornithes appeared in 1880, and that of the Dinocerata in 1885. The others were left in various stages of incompleteness at the time of his death. The proposed volumes treated of the Sauropoda, the Brontotheridæ, the Stegosauria, Theropoda, Ornithopoda, Mesozoic Mammals, and the Ceratopsia. Most of the investigations had been completed, a large part of the plates and figures engraved, and preliminary descriptions published, but the philosophical and phylogenetic problems are largely untouched. The loss to science is greatest in the volumes relating to Reptiles, especially the Dinosauria, for in this subject Marsh stood as the sole possessor of an acute and comprehensive knowledge of one of the most wonderful and difficult groups of vertebrates known. He planned his life-work on the basis that immortality is here and not in the hereafter. It seemed difficult for him to realize the limitations of human existence and worldly accomplishment.

In the closing years of his life he had two ruling ambitions,—first, to see the main building of the Museum erected, and, second, the completion of his monographs. The accomplishment of the first is imperative and would permit of the proper care and display of the priceless treasures he has accumulated. The attainment of the second would cancel his obligations to science. Neither was realized.

As one of the trustees of the Peabody Museum and as Curator of the Geological Collections, Marsh performed his chief duties in connection with Yale University. The final transfer to the University, of all the collections he had accumulated, was made January 1st, 1898, and soon after the gift was accepted by the Corporation. These collections are so extensive as to merit particular attention, especially since they represent the most valuable part of the work of a lifetime, and form the chief monument of one of Yale's most noted men. As expressed in the deed of gift, the collections comprise:

1. *The Collection of Vertebrate Fossils.* This is the most important and valuable of all. It is very extensive and contains a large number of type specimens, many of them unique, and is widely known from the descriptions already published. In extinct Mammals, Birds, and Reptiles, of North America, this series stands preëminent. The collection was pronounced by Huxley, who examined it with care in 1876, to be surpassed by no other in the world; and Darwin, in 1878, expressed a strong desire to visit America for the sole purpose of seeing it. Since then it has been more than doubled in size and value, and still holds first rank. The bulk of this collection was secured in western explorations, which were extended over a period of nearly thirty years.

2. *The Collection of Fossil Footprints.* These specimens are mainly from the Connecticut Valley, and thus have a special local interest.

3. *The Collection of Invertebrate Fossils.* This includes a large amount of interesting material from many formations and localities, both in this country and in Europe. Among the series of specimens especially valuable may be mentioned several thousand from the famous Mazon Creek locality in Illinois; a very extensive collection of Crinoids from Crawfordsville, in Indiana; the largest collection of nearly entire Trilobites yet discovered; and one of the rarest series of Silurian Sponges known, including important type specimens.

4. *The Collection of Recent Osteology.* This is believed to be one of the most complete collections in this country for purposes of study. Special efforts have been made for many years to secure the skeletons of rare existing vertebrates from every part of the world, particularly of Mammals; Birds, and Reptiles. The collection is especially rich in Anthropoid Apes.

5. *The Collection of American Archeology and Ethnology.* This collection is replete in Central American antiquities, comprising several thousand, many of them unique. Among others is the famous deZeltner collection from the same region, containing a number of gold ornaments. The specimens from Mexico are also of great interest, and the series is a representative one. It includes the well-known Skilton collection.

6. *The Collection of Minerals.* This is a limited collection, but contains many valuable specimens, among them probably

the most interesting series known of Nova-Scotian Zeolites. These were mainly collected by Marsh, before he was graduated at Yale, during six expeditions to Nova Scotia.

Besides the six main collections named, there are several others of less value, which include fossil plants, casts of fossils, geological specimens, and recent zoological material.

To these should be added the results of his last work in endeavoring to increase the scope of the material in the Peabody Museum. For many years it was his desire to secure a collection of fossil Cycads, and when the opportunity offered, he embraced it with characteristic vigor, so that within the last year and a half the Museum has received an amount of material which in importance and quantity is second to none.

From their extensive and varied nature, these collections thus presented to the University will long afford abundant material for original investigations, and will ever attract to New Haven specialists in Paleontology and Archeology.

Professor Marsh's life was remarkably free from the petty annoyances of poor health which so often interfere with human comfort and ambitions. In the midst of his scientific work and while making plans for the growth of the Museum, he was suddenly overtaken by the malady which resulted in his death. He died of pneumonia, on March 18th, 1899, in his sixty-eighth year, after an illness of about a week. His work as an investigator in natural science, his wonderful scientific collections, and his munificence to Yale, are his legacies to the higher education of mankind.

Although Marsh was an ardent collector in Archeology, he published very little on this subject, and his paper (1866) on an Ancient Sepulchral Mound near Newark, Ohio, is practically the only one. His three mineralogical papers, published between 1861 and 1867, show the results of considerable labor and careful investigation. They treat of the Gold of Nova Scotia, a Zeolite mineral from the same region, and a catalogue of the mineral localities of the maritime provinces of Canada.

In the field of Invertebrate Paleontology, he likewise was an indefatigable accumulator of material, though after 1869 he

published nothing in this department. Two papers presented some Annelids considered as new, from the Jurassic of Germany. Another showed the origin of the double lobe-lines in *Ceratites*. His papers on American invertebrates comprised a description of a new genus of Fossil Sponge (*Brachiospongia*), a new form of Crustacean Trail from the Potsdam Sandstone, and a note on color markings in *Endoceras*. He also showed that *Palaeotrochis* and *Lignilites* were not of organic origin, though the contrary had been previously supposed.

In the domain of Geology, his chief interests lay in the formations from which he secured important series of fossil vertebrates. Probably his greatest geological discovery was the Uinta Basin, an Eocene deposit of the eastern Uinta Mountains. It was first visited in 1870. Having studied most of the Tertiary lake basins in the Rocky Mountain region, he gave, in 1875, a synopsis of their geological features. As a natural result of studying Geology in Germany, he was much impressed with the methods of marking the separate horizons by means of some characteristic fossil. He believed the vertebrates were the most sensitive time-markers, and therefore endeavored to determine and limit geological horizons wholly by fossil vertebrate remains. The inherent fault of this system is that the vertebrates are not always the most highly differentiated and specialized types in any given fauna, and it is these qualities alone that can be safely employed in organic chronometry. This method is usually of great value in fresh-water deposits rich in vertebrate remains, but it can be seldom used to advantage in marine sediments or in formations containing a scanty vertebrate fauna. Thus, while the name *Equus* Beds is very appropriate for a horizon in the Pliocene, on account of the abundance of remains of fossil horses, the same cannot be said of the term *Eosaurus* Beds as an equivalent of the entire series of the Coal Measures, especially as but two vertebræ of this animal have ever been discovered. Geological facts will be found scattered through many of his publications dealing principally with fossil vertebrates. One of the latest problems to interest him was the age of the series of variegated clays extending from Martha's Vineyard south along the Atlantic coast into Maryland. His investigations led him

to refer them to the Jurassic, a formation which had been considered as absent in eastern North America.

There yet remains for consideration the real work of his life,—his publications on the Fossil Vertebrates, and it is at once evident, from a glance at the bibliography, that his chief researches were upon the Reptiles, Birds, and Mammals. There are three papers on Fossil Fishes, containing notices of several new forms, but no real research in this class was ever undertaken by him. The Amphibians also claimed but little attention, and his observations on the metamorphosis of the recent *Siredon* into *Amblystoma*, and two brief notices of amphibian footprints in the Devonian and Carboniferous, comprise the whole.

It is with extreme hesitation and a sense of inadequacy that the writer ventures to review, even in the briefest and most superficial manner, the work which undoubtedly constitutes the literary essence of his life-work. Future investigators alone can critically estimate the great mass of facts which Marsh brought out and which he wove into the departments of fossil Reptiles, Birds, and Mammals.

His most comprehensive work, and in many ways the most masterly, is the address delivered before the American Association for the Advancement of Science, at Nashville, in 1877. In this paper, entitled the "Introduction and Succession of Vertebrate Life in America," he traced the introduction of the various types of vertebrate life then known in America, beginning with the lowest fishes and ending with man. The amount of knowledge on the lower classes of vertebrates, including the reptiles, was then too meager to enable him to give more than occasional hints as to their phylogeny. But his handling of the Mammalia showed the clearest insight into the development and affinities of many of the important types, and marked him as a true philosopher.

A glance at the modern text-books of Geology and Paleontology reveals how much America has done for the fossil vertebrates in the three classes of Reptiles, Birds, and Mammals. It will also show that Marsh contributed more than any other investigator toward the prominence now accorded to the American forms.

His work on the Reptilia is not equally divided among the various orders, for the Dinosauria claimed his attention above all others. To this group he lent his best efforts, and he compassed it so thoroughly as to be its sole master. It seems only necessary in this place to notice the complete restorations he made of some of these remarkable animals. In this list are included *Anchisaurus*, *Brontosaurus*, *Laosaurus*, *Ceratosaurus*, *Camptosaurus*, *Stegosaurus*, *Triceratops*, and *Claosaurus*. It must be remembered that nearly all these animals were of gigantic stature, some of them the largest land animals yet known, and also that each restoration represents a number of separate investigations on the structure of the skull, the limbs, the vertebræ, the pelvis, etc. In most cases, only by this means was it possible to bring together gradually, part by part, until the sum of the knowledge warranted a complete representation of the skeleton. The material of many of the genera he described is still in these various stages of progress, awaiting new additions of portions yet unknown in order to form a finished conception of the entire animal. His extensive report on the Dinosaurs of North America, published in 1896, gave a synopsis of what he had accomplished up to that time, but as remarked elsewhere their philosophical treatment he had reserved for his final monographs.

Probably, among the Reptilia, next in importance to his work on the Dinosauria is that on the Mosasaurs. In this he first announced the discovery of the dermal armor, the position of the quadrate, the finding of the stapes, the columella, the hyoid, the sclerotic plates, the quadrato-parietal arch, the malar arch, the transverse bone, the pterygoids, the pterotic bone, the sternum, the anterior limbs, the posterior limbs, the length of the neck, and details of the pelvic region. Thus he contributed a knowledge of some of the most essential characters of the skeleton in this group. In other groups of aquatic reptiles, he also brought out new genera and types of structure. Prominent among these may be mentioned *Baptanodon*, a toothless Ichthyosaurian. Marsh was the first to describe the remains of fossil serpents in the western Tertiary deposits, and likewise the first to discover the remains of flying reptiles in America. The latter were of unusually large size and remarkable for the absence of teeth.

The acquisition of a unique specimen of Pterodactyl from the lithographic slates of Bavaria enabled him to supply the long sought information regarding the wing and caudal membranes. Notices of a number of new species of fossil Crocodiles, Lizards, and Turtles, complete this survey of his work on the Reptilia.

Practically, most of the present knowledge of extinct bird-life in America is contained in Marsh's publications, which include descriptions of numerous species, ranging from the Jurassic to the Post-Pliocene. Unquestionably, the one discovery which is always foremost in men's minds in a consideration of his work is the determination of an extinct order of birds possessed with teeth. The study of the Dinosaurs and Toothed Birds showed that one by one characters considered as avian were likewise present in reptiles, and that many reptilian characters were present in these primitive birds; so that at the end there did not seem much else besides feathers to distinguish them. Marsh's investigation of fossil birds led to the publication, in 1880, of his first monograph, "Odontornithes: a Monograph on the Extinct Toothed Birds of North America." In this volume, he carefully figured and described all the known types, and presented complete restorations of the two leading genera, *Hesperornis* and *Ichthyornis*. He concluded that birds most nearly resemble some of the small Dinosaurs from the American Jurassic, and that both classes originated at least as far back as the Trias or late Paleozoic, in some sauropsid type.

A discovery which rivaled that of the Toothed Birds, although not so wholly his, was the genealogy of the Horse. Huxley and Kovalevski traced the equine branch through the Pliocene to the Upper Miocene in Europe, but the true and remote ancestry remained unsolved until the American types were described by Marsh. He showed that a primitive and diminutive polydactyl horse existed in the Lower Eocene, and that from this type, by gradual and progressive change through successive horizons of the Eocene, Miocene and Pliocene, there had been evolved all the intermediate stages leading to the modern horse.

Next in importance and interest should be noticed the series of papers culminating in the monograph of the Dinocerata,

issued in 1886 by the United States Geological Survey. His work in other groups of mammals is scattered through a large number of separate papers, and contributions were made to every known order. The Tillodontia comprise one of the most remarkable of the types. Among others are the first remains of fossil Primates, Cheiroptera, and Marsupialia, known from North America. The Brontotheridæ and Coryphodontia received considerable attention. A monograph had been begun on the former, and restorations of a typical genus of each were published.

One general conclusion of much significance was the outcome of his researches on the Mammals. It was that the Tertiary genera possessed very small brains. As a single example, *Dinoceras* may be taken. This animal was but little inferior to the elephant in bulk, but its brain capacity was not more than one-eighth that of existing rhinoceroses.

The first Mesozoic Mammal in America was described by Emmons, in 1857, from the Triassic of North Carolina. Marsh, by his extensive discoveries, was enabled to fill up the gaps to the Tertiary with many genera and species from the western Jurassic and Cretaceous. Probably nine-tenths of all the Mesozoic Mammals known in the world were described by him, and while these remains are of great interest, yet from their fragmentary condition they are not of the highest scientific value, because little is known beyond the jaws and a few limb bones.

In closing the outline of the discoveries made by this investigator, one cannot help being impressed with their signal brilliancy, their great number, and especially by their unique importance in the field of organic evolution. Were all other evidence lost or wanting, the law of evolution would still have a firm foundation in incontrovertible fact. The study of variation and embryology in recent animals gives hints as to the truth, but Paleontology alone can give the facts of descent.

CHARLES E. BEECHER.

YALE UNIVERSITY MUSEUM,
NEW HAVEN, CONN., May 1st, 1899.

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